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FOUNDATIONS FOR FARM AND VILLAGE DWELLINGS

A report submitted to the

PRESIDENT'S CONFERENCE ON HOME BUILDING AND HOME OWNERSHIP

by the

Committee on Farm and Village Housing

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FOUNDATIONS FOR FARM AND VILLAGE DWELLINGS [a]

This paper presents a brief description of accepted practices in the construction of small-house foundations. Well-designed and constructed foundations go far to lessen depreciation of houses and to prevent such troubles as wet cellars, bulged or cracked walls, broken plastering, warped floors, sagging doors, and sticking window frames. Choice of materials depends on their availability and cost, and the character and value of the house. Permanent foundations can be constructed of stone, brick, structural tile, concrete, or solid or hollow concrete blocks. Log or post supports are much used for low-cost houses in timbered localities. Wood foundations, if used, should be of the more decay-resistant kinds or be protected from decay and damage by termites, especially in moist locations and warm climates, by use of chemical preservatives. [b] A heavier and more expensive foundation is required for a house with a cellar than for one with none. In low wet ground the cost of adequate drainage or waterproofing of a cellar may be high. However, a good dry cellar may add much to the value of a house.

Selection, Drainage and Grading of Sites [c]

Where a choice of sites is possible preference should be given to a location having surface slope and good drainage. Spongy or peaty land and filled ground, unless well settled, are unsuitable for foundation beds.

Wherever the ground water is near the surface, a cellar needs a 4-inch tile drain around the outside of the bottom of the foundation. (Fig. 1.) The drain should have an adequate outlet. Refilling the trench of the foundation drain with broken stone or screened gravel, thus placing a belt of coarse material around the cellar, is a great aid in collecting and carrying off seepage water and intercepting dampness from the adjacent ground.

Surface water should be turned away from the house by grading. Sod and top soil should be piled separately, and after the subsoil has been graded to form a smooth slope, extending at least 10 feet from the house, should be used for final grading and lawn making. Short drains or shallow concrete or tile gutters should be laid from the downspouts.

(a) By G. M. Warren, T. A. H. Miller, and Wallace Ashby of the Bureau of Agricultural Engineering, U. S. Department of Agriculture.

(b) See references (1), (3), and (8), page 8.

(c) See reference (4), page 8.

Design and Construction

The foundation of a house may consist of masonry walls, a series of piers or a combination of both. The required thickness of wall and the size and number of piers depend upon the material used, the weight of the house and the bearing power of the soil. If there is no cellar, plain walls 8 inches thick started on firm ground below frost depth are generally sufficient. The top should be at least 8 inches above the surrounding ground, and greater height may be necessary for proper grading. The walls should have ample screened openings above ground and on opposite sides, to ventilate the enclosed space thoroughly.

The base of the wall should be placed on firm, dry, level soil or bed rock. A hillside location may necessitate stepping the bottom to save masonry and make the base horizontal. It is generally advisable to tamp the bottom of an excavation, although tamping softens some fine soils when wet and makes them less stable.

A footing course or flat, widened base as shown in Figure 1 is often needed to distribute the load, provide a good working surface upon which to construct the wall, and if there is a cellar, resist tipping of the wall. The design of footings and walls should be based on the character of the underlying soil and the imposed weight. In ordinary practice the bearing power of soils is assumed as follows: For hardpan or firm dry sands, clays, gravels or mixtures of them, not more than 3 tons per square foot of bearing area; for ordinary well-drained subsoils, not more than 2 tons; for alluvial soils or wet clay, not more than 1 ton. Local experience may indicate the need of smaller loadings or may possibly justify larger loadings. Unless a foundation rests on bed rock some settlement may be expected but in every instance all reasonable effort should be made to render the settlement slight and uniform.

The total weight of a fairly well-constructed two-story frame house with contents may vary from 100 to 150 pounds per square foot of floor area, and normally about three-fourths of the load is carried on the outer walls. (d) Having estimated the weights and the bearing power of the soil as given above, the width of the footing is computed. However, for ordinary one and two-story buildings with full-depth cellars it is seldom advisable to make the footing course less than 14 inches wide and 6 inches thick.

Footings are usually of concrete and project equally from both sides of the wall. Unless reinforced with steel their thickness should be approximately equal to the width of the footing minus the thickness of the wall. Thus, a footing designed to support an 8-inch wall might be 14 inches wide and 6 inches thick. On a poorly drained

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(d) See reference (9), page 8.

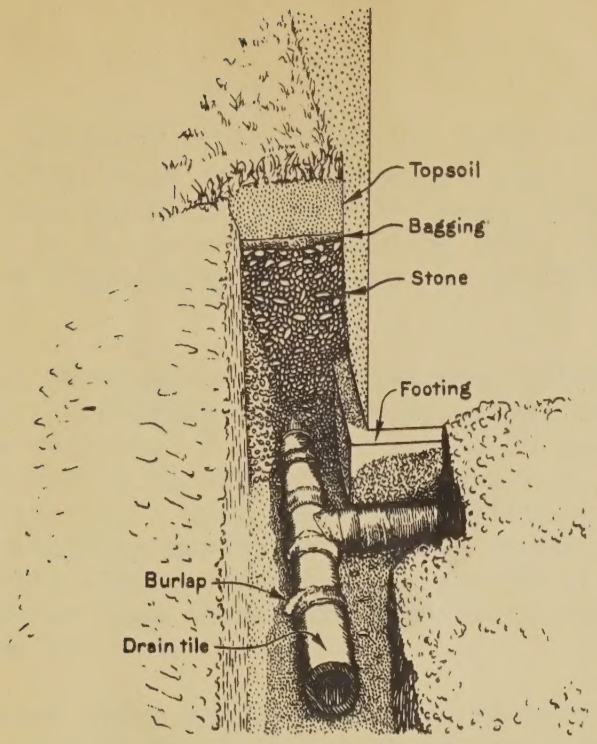

Figure 1.– A good drain along the outside bottom of the foundation

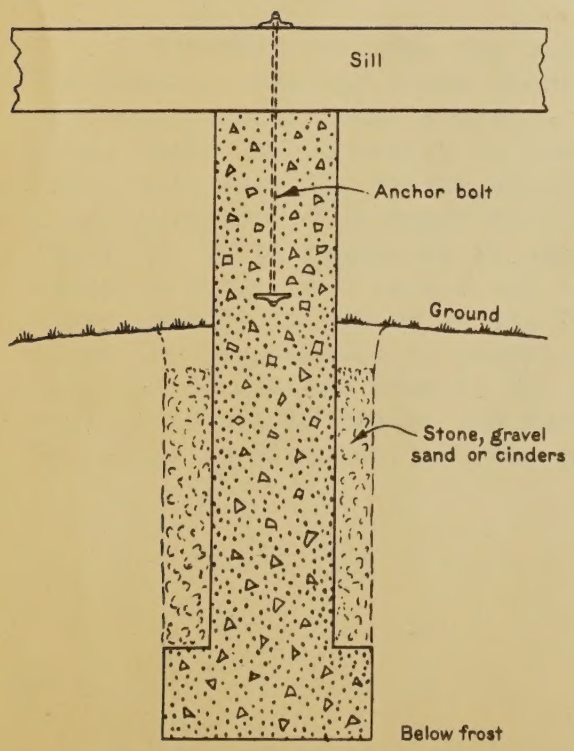

Figure 2.– Good pier construction

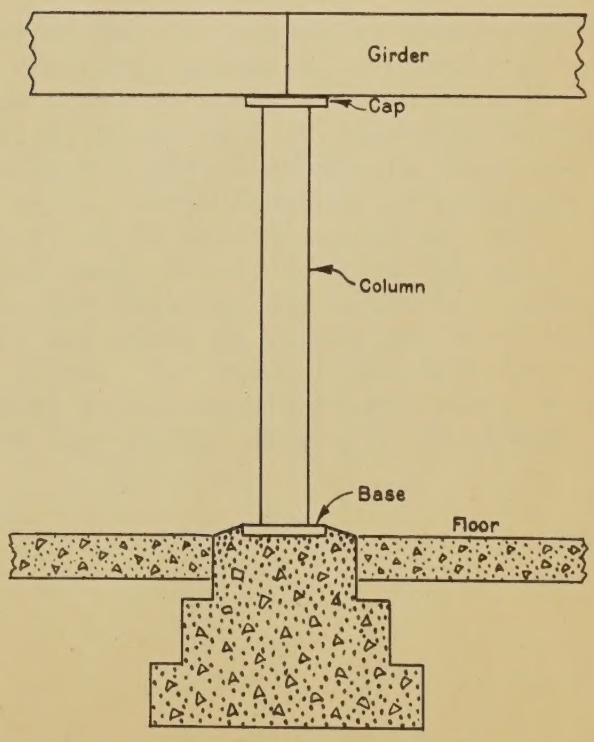

Figure 3.– Column and stepped footing independent of floor

soil it might be necessary to increase the width of the footing to 20 inches and the thickness to 12 inches putting it down in two 6-inch layers. When the first layer, 20-inches wide, has partly set the second layer, 14 inches wide, should be laid, to center on and bond with it, thus stepping the sides in the proportion indicated above.

Recommended thicknesses for full-depth, exterior cellar walls to support ordinary one-story or two-story houses under average soil conditions are as follows: For rubble stone, 16 inches; for brick solid or hollow concrete blocks, or structural tile, 12 inches; for well-made solid concrete - 8 inches. In localities subject to heavy gales heavier foundations may be necessary. On the other hand, 8-inch brick, concrete block, or tile walls are often used satisfactorily for bungalows and cottages where soil conditions are favorable and damage from storms is rare.

In localities where heavy storms are prevalent, the house should be secured to the foundation by 3/4-inch anchor bolts placed 6 to 8 feet apart and set about 18 inches in the wall. If the foundation is of concrete blocks, or tile, the bolts should extend through at least two courses. Whenever hollow units are used they should be filled with concrete at anchor bolts and beneath floor beams or other concentrated loads. Mortar in foundation masonry should have a strength not less than that of a cement-lime mortar composed of one volume of good Portland cement, one volume of lime putty or hydrated lime, and six volumes of clean sand. The mortar should be thoroughly mixed to uniform quality.

Concrete has wide and satisfactory use in foundation construction. The cement, sand and stone should be carefully selected, correctly proportioned and thoroughly mixed. Fresh Portland cement; clean, coarse sand, washed if necessary to remove clay, silt, loam or vegetable matter; and clean, durable, broken stone or screened gravel graded in size from $\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter should be used. Where footings or walls are thick and water tightness is unimportant it is economical to use some stone as large as 2 inches and to imbed small field stone in the concrete when it is placed in the forms. For footings and walls not water-tight the proportions of cement, sand, and stone by volume may be varied with the conditions from 1: $2\frac{1}{2}$: 5 to 1:3:6. For water-tight work the mixture should be richer and the largest stones should range from 1 to $1\frac{1}{2}$ inches in diameter. If the maximum size of the stones is $1\frac{1}{2}$ inches

the proportion may approximate 1:2½:3½ which is suitable for foundation walls below or above ground. If the maximum size is 1 inch, the proportion may approximate 1:2:3 which is also suitable for water-tight cellar floors.

In mixing concrete the smallest quantity of water that makes the product workable, plastic and uniform should be used. Excess water weakens concrete and makes it more porous. As soon as mixed, the product should be placed in layers 6 to 10 inches in depth, worked with a spade, and lightly tamped to make the mass dense and uniform. Working the spade up and down along the form pushes the stone back slightly and brings the grout (liquid cement) against the face, thus preventing an unsightly honeycombed appearance. The concrete after being placed should be protected from sunlight, frost and wind, any of which rob it of moisture and prevent proper setting. Curing concrete by keeping it thoroughly wet for 7 or more days is very important. Frequent wetting of a covering of burlap, hay or straw, is the usual method. Wall forms should be left in place until the concrete is thoroughly hardened. Concrete floors can usually be cured most effectively by covering with wet burlap kept wet or by ponding with water to a depth of an inch or more.

Making concrete and other masonry water-tight and damp-proof requires the very best workmanship. The use of water-proofing fabrics and bituminous coatings and the preparation of stone, brick, tile or block walls for the application of damp-proofing paints and Portland cement plastering are discussed in reference (4). These methods are for excluding water. They do not excuse the making of foundations less substantial than may be necessary to guard against settlement and heaving by frost. (c)

Piers

If houses are supported by piers (Fig. 2) instead of walls, less excavation and masonry are necessary but such foundations often lack stability because of too few piers, insufficient area and depth of footings or poor construction. Piers and pier footings should be proportioned to the weight of the building. The footing should be below frost depth and in firm ground. In cold localities and wet clay soils where heaving by frost is pronounced, the sides of piers are sometimes battered like a pyramid and the excavation refilled with cinders or gravel to lessen the heaving effect. Battering the sides or stepping them reduces the quantity of masonry, but in concrete work may slightly increase the cost of forms. Ready-made concrete piers are obtainable of dealers in some localities.

(c) More complete information on the construction of foundations and footings is given in references (2), (4), (5), (6), (9), (10), (11), (12), (13), and (14), page 8.

Within cellars wood posts, steel or cast iron columns or pillars of brick or concrete frequently support part of the weight of the superstructure. A house having a central column or pillar may have one-fourth of its total weight so supported.(f) This load in an ordinary frame house may be 12 or more tons requiring that the footing of the column be at least 2 feet square in firm ground having a bearing capacity of 3 tons per square foot, and larger where the conditions are less favorable. Columns and pillars should not rest on floors but should have independent support on footings (Fig. 3) of ample size to avoid greater load per square foot of bearing soil than that under the walls. In general, it is advisable to space columns not more than 8 to 10 feet apart.

The unsupported height of brick or plain concrete pillars should not exceed ten times their least horizontal dimension. The minimum size of brick pillars laid in cement mortar should be 12 by 12 inches and 10 by 10 inches for plain concrete. Pillars of hollow tile or hollow cement blocks should be solidly filled with concrete and their unsupported height should not exceed eight times their least dimension. Masonry pillars should be of the best construction and should be capped with a 4-inch slab of richly mixed concrete or have a metal bearing plate. When constructed of rubble stone they must be very large and especially well bedded and bonded in good Portland cement mortar. Wooden posts should be strong durable timber at least 6 inches square. The bottom of a wooden post should rest squarely on the top of a concrete footing 3 or more inches above the cellar floor and should be doweled to the footing. The top of the pier should be sloped downward from the sides of the post to shed water.

Chimney and Fireplace Foundations

A chimney or fireplace foundation should be sufficiently large to support the weight without subjecting the soil to greater pressure than that under the main foundation. A 6-inch projection outside the chimney or fireplace wall on all sides is usually ample. The foundation should be laid in firm ground below frost depth. If there is a cellar, it should be as deep as the main walls and below the cellar floor.

There are advantages in locating chimneys away from external walls, thus conserving heat and tending to improve draft. A separate flue should be provided for each heating unit and all flues should be tightly lined with fire clay linings, obtainable in 2-foot sections or lengths of various size. The minimum size recommended for stoves and ranges is $8\frac{1}{2}$ by $8\frac{1}{2}$ inches (flue area 49 square inches); for

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(f) Reference (9), page 8.

furnaces and fireplaces 8½ by 13 inches (flue area 76 square inches). If no lining is used the flue should be tightly plastered inside.

Two or more linings in a chimney are preferably separated by 4-inch brick or concrete walls. (g) If not so separated the horizontal joints should be staggered approximately 1 foot and all space between adjacent linings and between linings and brickwork should be completely filled with soft mortar or grout. One section of lining at a time bedded in good mortar should be placed and the wall should then be built up around that section. Before placing the next section the bedded joint should be smoothly pointed on the inside. The minimum thickness of brick chimneys 30 feet or less in height and not exposed to the weather should be 4 inches in addition to the flue lining. If unlined or if exposed to the weather the walls should be of the best construction and not less than 8 inches thick.

Modernization and Repairs

It is frequently desired to make a cellar under an old house or to repair defective foundation work. Such work is best done by a reliable builder who has the needed tools and experience, but sometimes can be done at comparatively small cost by home methods. The building or the settled part should be lifted with screw jacks and the necesssary props, shores or beams. A sufficient number of jacks, with heavy blocking, should be used to avoid distortion and damage of the superstructure. Lifting should be to full, level position of sill and floor beams. If a cellar is to be made the building should be temporarily supported by heavy timber cribbing, so located that excavation and construction of the foundation walls may proceed without difficulty as previously described for new work of like character. If the work is merely repair of a corner or pier it is usually unnecessary to construct a timber underpinning. After the new masonry has set hard, sills should be shimmed and bedded in cement mortar, piers should be capped and beams should be wedged. Underpinning and jacks should not be removed until all weight can be safely supported on the shims and mortar beds.

A small cellar or pit in which to set a furnace is all that some desire. In such instances it is common practice to lay an 8-inch brick or concrete curb 3 or 4 feet high to enclose the space and slope the earth upward to meet the original surface at the outer walls. If the pit is close to a wall it is usually advisable to omit the curb on that side and carry the wall to the full depth.

Repair of foundations may loosen plastering, crack wall paper or warp wood work. Decorations and repair of the superstructure should await permanent repair of foundations. Good foundations seldom need repair nor can repair work be done as cheaply as new work.

(g) See references (5), (7), (9), and (10), page 8.

Publications Cited

Farmers' Bulletins - U. S. Department of Agriculture

(1) 744-F Preservative Treatment of Farm Timbers
(2) 1279-F Plain Concrete for Farm Use
(3) 1472-F Preventing Damage by Termites or White Ants
(4) 1572-F Making Cellars Dry
(5) 1590-F Fire-protective Construction on the Farm
(6) 1638-F Rat-proofing Buildings and Premises
(7) 1649-F Construction of Chimneys and Fireplaces
(8) 1660-F The Use of Logs and Poles in Farm Construction

Farmers' Bulletins are mailed free while the supply lasts upon application to the United States Department of Agriculture, Washington, D. C.

Other Government Publications

(9) Bulletin 145, Light Frame House Construction, published by the Federal Board for Vocational Education and for sale by the Superintendent of Documents, Washington, D.C. Price 40 cents.

(10) Recommended Minimum Requirements for Small Dwelling Construction, Report of Buildings Code Committee, Department of Commerce and for sale by the Superintendent of Documents, Washington, D. C. Price 15 cents.

Trade Publications

(11) Publications of Portland Cement Association, 33 West Grand Avenue, Chicago, Illinois. Offices in principal cities.

(12) Publications of The Common Brick Manufacturers' Association of America, Cleveland, Ohio.

(13) Publications of Structural Clay Tile Association, 205 West Wacker Drive, Chicago, Illinois.

(14) Publications of the National Lumber Manufacturing Association, Transportation Building, Washington, D. C.